

Gaia 11 kW Wind Turbine Operating in a Diesel Grid and as Stand Alone Turbine

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The Gaia project

- **Project data**
- **Background**
- **Objective**
- **Main project elements**
- **Project status**
- **Stand-alone concept**
- **Next steps**

Project data

- **Partners**

- Wind Energy Department, Risø (Project Coordinator)
- Gaia-Wind A/S
- Mita-Teknik A/S
- Institute for Energy Technology , Aalborg University

- **Project period**

- 1 January 2001-30 June 2003

Background I

- **World-wide there is a very large need for rural electrification**
 - Approx. 2 billion people are without electricity
 - Their basic needs can be covered by 1000TWh (equiv. to 7% of the worlds electricity production)
 - 4-25% of the population in sub-Saharan Africa has electricity (and mainly in the urban areas)
 - Many villages in the developing world has no power at all
 - The cost of connecting them to a central grid is often too high
- **In many of these places wind resources are good**
- **Wind energy will often be the most attractive (renewable energy) alternative for villages and communities**
 - pv will often be too expensive at larger system sizes (10kW and up) whereas wind energy typically will be cheaper a sized is increased
- **The sites will often have very difficult infrastructure**
 - access: places are often remote and roads are bad
 - skills: The experience at the villages with technical equipment is limited
 - economy: the economy is often not well developed and it can make it very difficult to provide the basis for a economically sustainable power system
- **There is therefore a need for robust and well-documented solutions**
 - Solutions should be suitable for operation in systems with other types of generation especially diesel gensets
 - There should also be solutions that does not require other units

Background II

- **More than 80 Gaia wind turbines have been installed in Denmark, and they have operated successfully for several years,**
- **One of them were monitored in the framework of a "household wind turbine" project under the Danish Energy Research Programme.**
- **Export orders are beginning to come in.**
- **Wind turbine manufacturer is owned by the same company that owns the controller manufacturer.**
- **Size of the wind turbine (11kW) fits many applications in rural electrification, village power systems, and in power system retrofitting in remote areas.**

Project objectives

- **Development of 11kW Gaia wind turbine for operation in a wind diesel system**
- **Development of a stand-alone version of the wind turbine**
- **Establish a basis for technical and economic performance assessment i.e. develop a technical-economic model**

Main project elements

- **Installation of wind turbine at Risø**
- **Measurements on wind turbine when connected to grid and wind-diesel system**
- **Documentation of wind turbine performance when operating in a diesel grid**
- **Specification and implementation of stand-alone system**
- **Documentation of stand-alone system performance**
- **Development of technical/economic performance assessment model**

Project Status

- **Wind Turbine has been installed incl. modification of electric switchboard and installation of cables**
- **Controller has been modified**
- **Grid connection module has been exchanged for more advanced version**
- **New measurement system and data acquisition system incl. new sensors has been installed**
- **Measurements when connected to utility grid has been done**
- **Wind turbine has run in wind diesel mode and performance has been measured**
- **Investigations of stand-alone systems layout has been executed and configuration has been chosen**
- **Specification of stand-alone system is well under way**
- **Development of technical-economic model has been initiated**

Gaia wind turbine

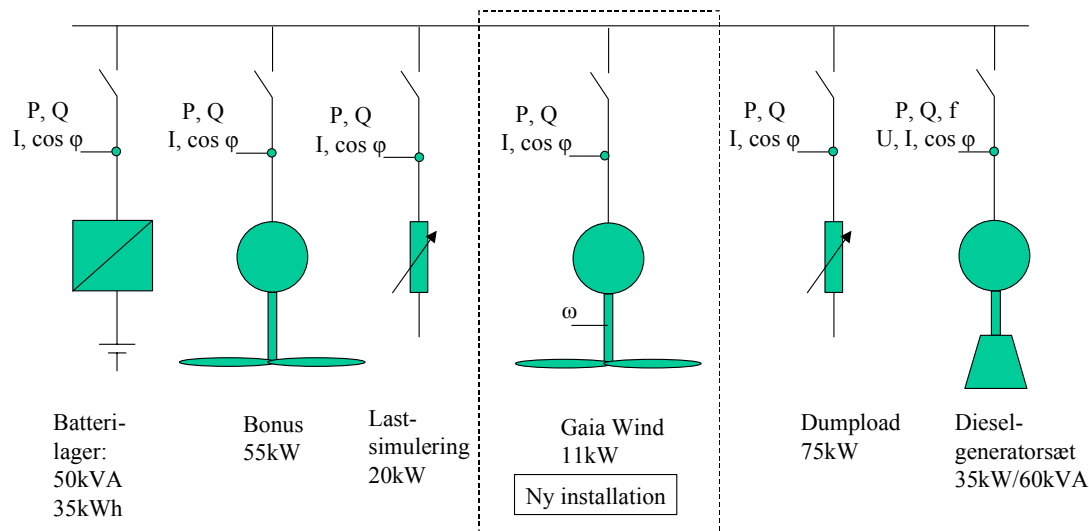
- **Main data**
 - 11kW
 - 2 bladed, diameter 13m
 - fixed pitch stall control
 - Teeter hub
 - Down wind, passive yaw
 - Induction generator
 - Hub height: 18m



Risø Test Facility

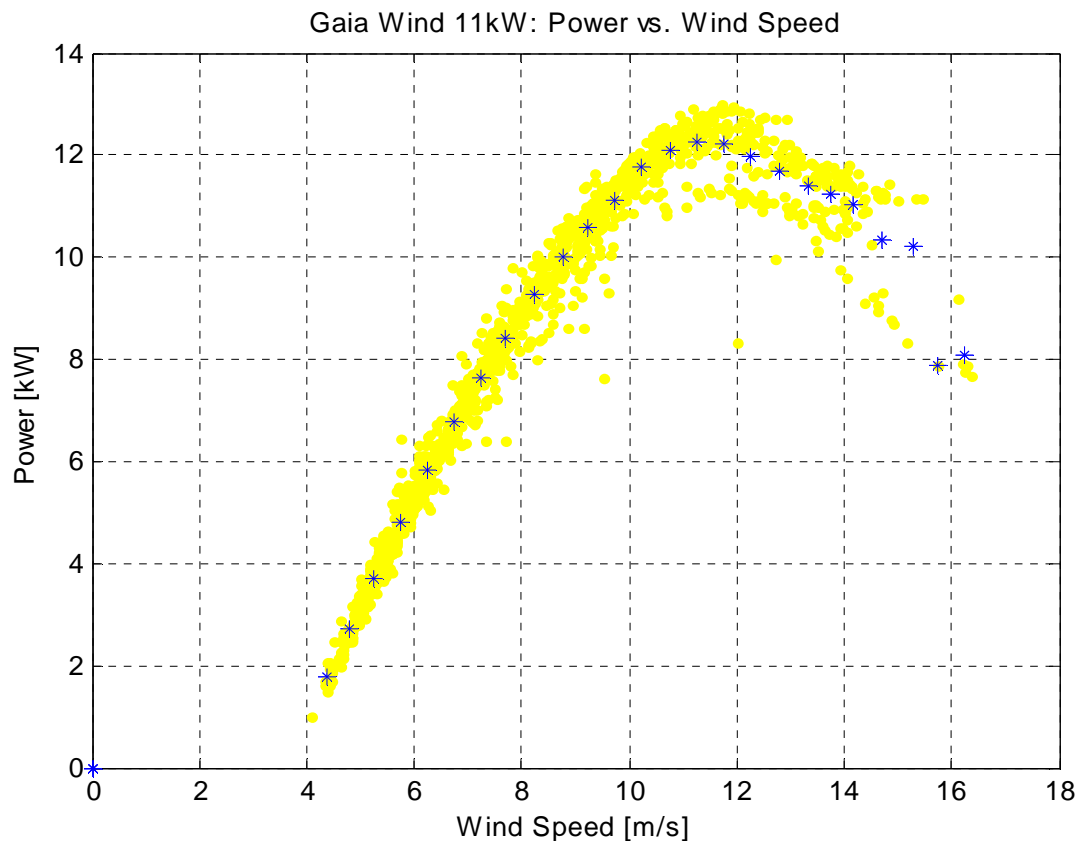
- 11kW Gaia wind turbine
- 55kW Bonus wind turbine
- 35kW Diesel genset
- Quite flexible
- Many measurement signals

Risøs vind-diesel testfacilitet - efter installation af Gaia mølle



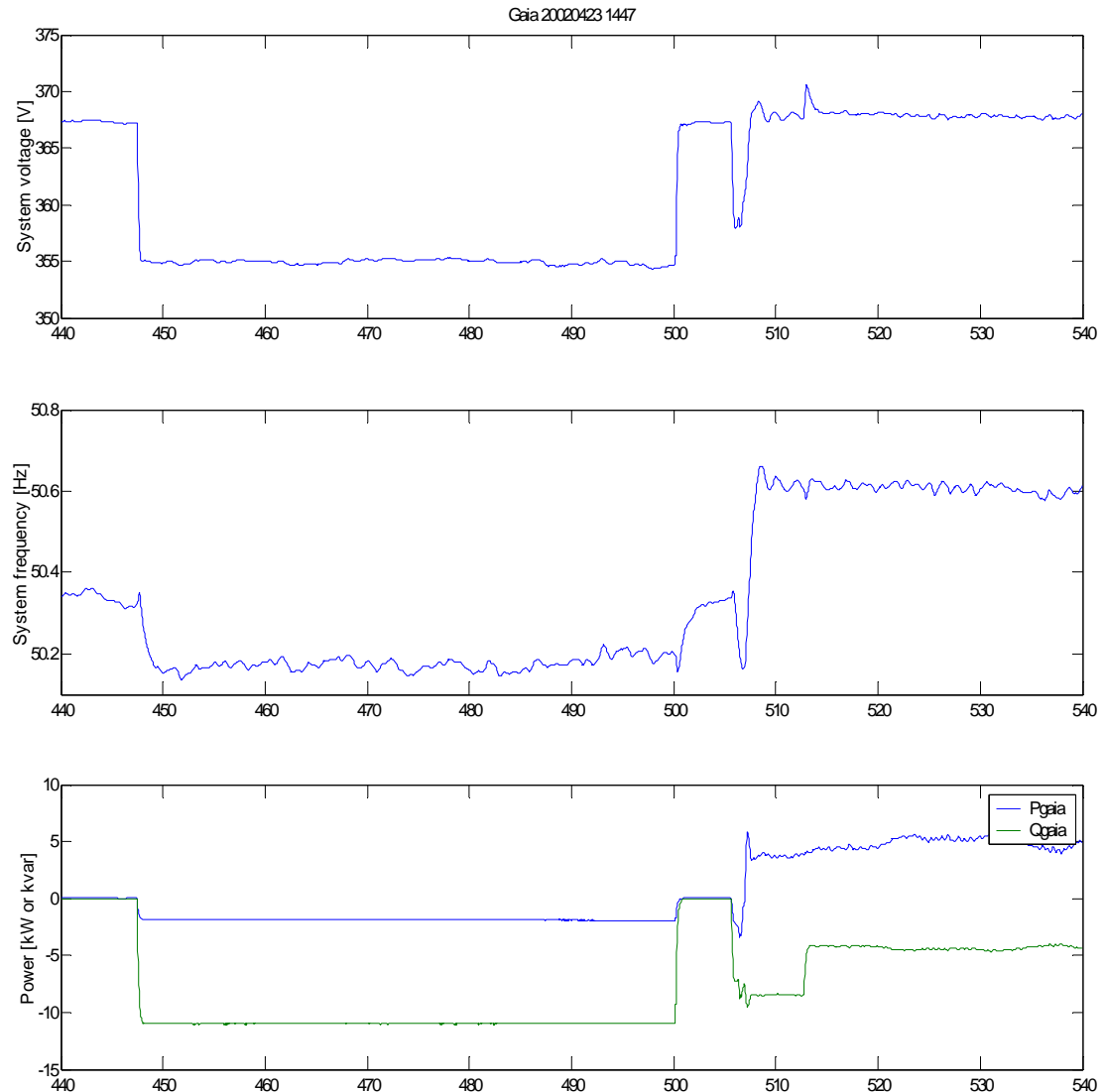
Preliminary power curve

- Power curve measured at Risø
- Based on 10min averages



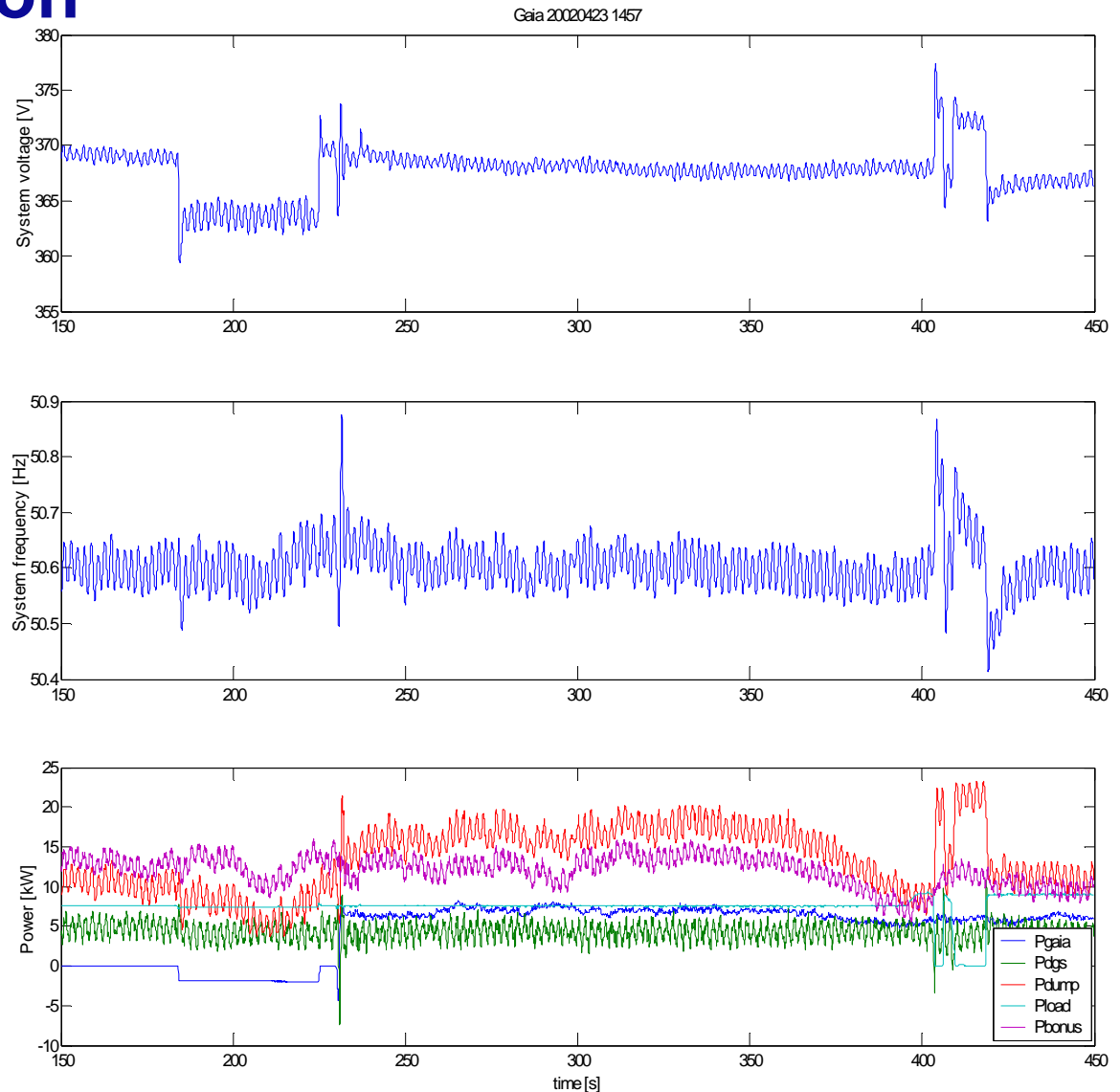
Connecting to a Diesel grid

- The grid connection phase is relatively long
- The current drawn during the initial acceleration is constant
- The actual connection is very gentle
- The impact on system voltage and frequency is very limited



Connecting to a wind diesel grid and normal operation

- Another (and larger turbine) is already connected
- The impact on frequency is very limited (less than step changes in the load (7kW))
- Operates very well in parallel with Diesel Genset and Wind Turbine



What is a stand-alone wind turbine

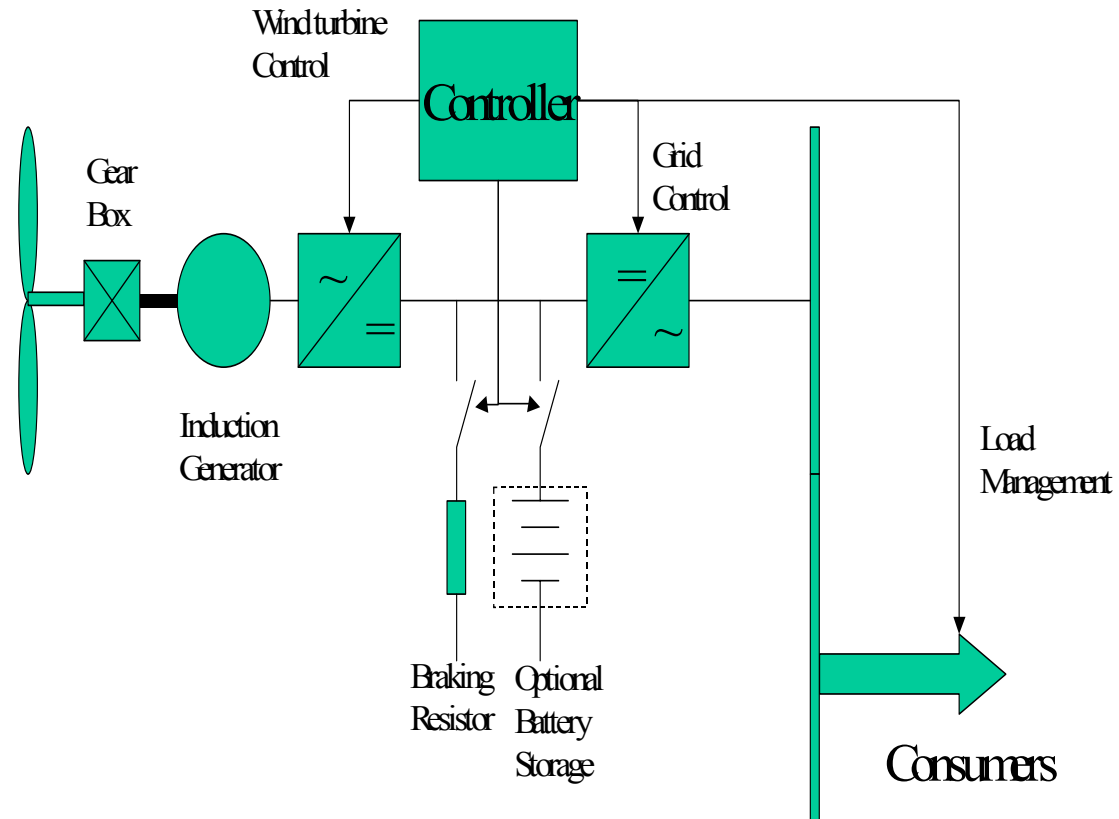
- **Standard wind turbines very often have induction generators connected directly to the grid**
- **Controllers of a standard wind turbine only controls the wind turbine and does not control the grid or a connected system**
- **Therefore the wind turbine depends on having other generators to control frequency and voltage and to handle scheduling and dispatch**
- **A stand-alone wind turbine is modified in order to be able to control the grid (frequency and voltage) and also to include some kind of supervisory controller to manage the complete system including load and other generators**

Stand-alone system requirements

- **Serve normal appliances: TV, tele, light etc.**
- **Deliver power of adequate quality**
- **Black grid start up**
- **Work in parallel with other generators**
 - synchronize to grid
 - participate in load sharing
 - isochronous and droop control
- **Control of f , U**
 - Good dynamic performance
 - Able pick up loads
- **Safe operation of unit**

Stand-alone concept and prototype

- Uses standard Gaia wind turbine
- Back-to-back converter for wind turbine and grid control
- Optional battery in the dc-link
- Controller for system and wind turbine supervisory control
- Prototype is able to operate both as a standard wind turbine and as a stand-alone
- dSpace is used for prototype dynamic controller development
 - Turbine control (rotational speed control)
 - Grid control (start up, sync, (f, U))
 - Dynamic unit control (incl. braking resistor and battery)



Next steps

- **Technical/economic modelling has been initiated**
- **Stand-alone version is being designed**
- **Work on establishing prototype has been initiated**
- **Dynamic modelling work has been started (for controller design)**